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My name is George Tamaro, I am senior partner at Mueser Rutledge Consulting Engineers. Our firm specializes in the investigation, design and inspection of underground structures. I am a registered professional engineer in the state of Massachusetts and sixteen other states. I have worked in underground construction for 38 of my 46 years in the industry.

Slurry wall construction is as much an art form as a construction technology. The technology was initially developed in Northern Italy in the early 50's and was first used in the US to a major extent at the World Trade Center in New York City.

Slurry wall construction is particularly useful for the installation of underground walls of both a temporary and permanent nature in urban environments and in difficult ground conditions. Slurry wall construction technology was particularly appropriate for the construction of the I-93 Central Artery Tunnel in Boston. The end product, by its very nature, is a rough textured, unfinished concrete wall. The end product is even more irregular and can be problematic if attempted by unskilled contractors.

Slurry wall construction is started from ground level and is carried down to predetermined depths. The work in done in the blind from ground level and requires intuition and a good deal of monitoring and testing of the process as it proceeds. Slurry wall construction can be expected to have some flaws as a result of this "in the blind" process. These flaws are usually observed during the general excavation, when the walls provide temporary support for the construction. Defects are usually repaired as the excavation is carried downward and should be completed prior to the incorporation of the slurry wall into the permanent construction. This is the procedure that should have been followed for the I-93 Tunnel.

Of immediate concern with the I-93 Tunnel are the problems associated with a number of slurry wall panels. The area of concern is the portion of slurry wall exposed from the top of the walkway to the underside of the roof where a defect in the slurry wall would permit flow of water and/or soil into the Tunnel. The defects are primarily in the slurry wall concrete. The steel beams that are the vertical spanning members are not affected by the defects in the concrete that spans horizontally from steel beam to steel beam. These structural concrete defects can not remain and must be repaired. The portions of the slurry wall above the roof and below the roadway are of no concern.

Field inspection records for one of the slurry wall panels (Panel EO-45, Contract C17A1) indicate that that panel was not constructed in accordance with the specifications and furthermore, the wall was not adequately repaired during general excavation. This defective panel remained stable until September 15, 2004, when the defect could no longer resist the external water pressure. The defect in the wall gave way and permitted the flow of water and soil into the I-93 Tunnel. The defect in the EO-45 panel is currently temporarily protected by wooden wedges, grout and a steel plate. Alternative permanent repair schemes are currently under review.

As a result of the incident of September 15, the project engineering team has inspected slurry walls along the tunnel alignment. Several major problems and a good number of minor "leaks" have been identified

In addition to the defects in the slurry wall concrete there is a problem of leakage at the contact between the concrete roof slab and the slurry wall. At several locations water has flowed down the face of the wall and onto the roadway, where, during the winter it freezes on the roadway. There is also a potential for corrosion at the roof girder connections. These connections are the main support of the roof system and will require regular inspection and maintenance throughout the life of the tunnel.

There is currently disagreement on the extent of the leaks and whether the leaks will be permanently sealed at the conclusion of construction. It is uncertain that a permanent sealing of the tunnel roof joint will be achievable.

The Committee on Government Reform has asked that I share my thoughts on quality control issues. I would like to share with you my experiences at the World Trade Center in 1967. I was the owner's engineer responsible for the construction of the slurry walls. I was working for the Construction Division of the World Trade Center Department of the Port Authority. My engineering group consisted of approximately a dozen people working 24-hours a day, 6-days a week on the construction of the walls. The wall schedule was absolutely critical inasmuch as the structural steel for the Towers was being fabricated and delivered to storage in New Jersey. It was my job to assure that the work progressed in a timely manner and was constructed in accordance with the contract documents. The Engineering Department assigned an additional 6 people to provide an additional independent layer of oversight on the work. I was responsible for quality control and the Engineering Department was responsible for quality assurance. The Engineering Department had the authority to stop the work if quality was an issue. In my opinion the Engineering Department personnel provided a beneficial supporting activity, two pairs of eyes would provide extra oversight and assure that the work was done correctly. Based on that experience, I recommend that on future major public works projects a group of owners engineers be assigned responsibility for quality control, independent of the project management, cost control and scheduling people and with authority to stop work if quality is compromised.

There is an old adage that states that, "quality will be long remembered after the schedule and the cost is forgotten." As a casual observer I am forced to conclude that the focus on the cost overrun and the schedule distracted attention from quality control issues on the Central Artery Project. It is now necessary to assure the public that quality issues are being addressed and that the public can use the tunnels without concern for their safety. This will not happen overnight.

Thank you for allowing me to testify today. This concludes my testimony. I would be pleased to answer any questions that the Committee may have.

George J. Tamaro, PE